Review of CHESS score in SAH patients in local Malaysian Population

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LIST OF ABBREVIATIONS

1.	CSF	CEREBROSPINAL FLUID
2.	CT	COMPUTED TOMOGRAPHY
3.	CTA	COMPUTED TOMOGRAPHY ANGIOGRAPHY
4.	CHESS	CHRONIC HYDROCEPHALUS ENSUING SUBARACHNOID HEMORRHAGE SCORE
5.	DSA	DIGITAL SUBTRACTION ANGIOGRAPHY
6.	CSF	CEREBROSPINAL FLUID
7.	EVD	EXTERNAL VENTRICULAR DRAIN
8.	GCS	GLASGOW COMA SCORE
9.	ICH	INTRACEREBRAL HEMORRHAGE
10.	IVH	INTRAVENTRICULAR HEMORRHAGE
11.	MAP	MEAN ARTERIAL PRESSURE
12.	MRI	MAGNETIC RESONANCE IMAGING
13.	NeuroICU	NEURO-INTENSIVE CARE UNIT
14.	OR	ODD'S RATIO
15.	PHH	POST HEMORRHAGIC HYDROCEPHALUS
16.	SAH	SUBARACHNOID HEMORRHAGE
17.	WFNS	WORLD FEDERATION OF NEUROSURGICAL SOCITIES

ABSTRAK

Latar Belakang dan Objektif

Pendarahan subaraknoid yang menyebabkan hidrosefalus kronik adalah satu keadaan yang boleh pulih semula dan dirawat. Sehingga kini skor klinikal yang sedia ada untuk meramal perkembangan hidrosefalus selepas pendarahan subaraknoid adalah terhad dan sukar digunakan dalam persekitaran klinikal. *Chronic Hydrocephalus Ensuing Subarachnoid Hemorrhage Score* (CHESS) diterbitkan pada tahun 2015. Walaupun ianya menunjukkan hasil yang memuaskan tetapi belum ada pengesahan dari mana-mana institusi selain dari benua Eropah. Kajian ini direkabentuk bertujuan untuk mengesahkan ketepatan dan kebolehpercayaan skor CHESS dan juga mencari faktor-faktor lain yang boleh menyebabkan hidrosefalus selepas pendarahan subaraknoid.

Kaedah

Seramai 130 pesakit dari 2 pusat neurosurgeri tertiari di Malaysia yang menghadapi pendarahan subaraknoid dianalisis dengan menggunakan parameter dalam skor CHESS. Skor CHESS telah diaplikasi secara retrospektif. Keputusannya dibandingkan dengan data klinikal pesakit yang mendapati *shunt* selepas menghidapi hidrosefalus selepas pendarahan subaraknoid. Hasilnya dianalisa menggunakan regresi logistik binari dan ujian *Goodness-of-Fit* untuk menentukan nilai ramalan dan pengedaran populasinya dengan data asal.

Keputusan

Sejumlah 31% pesakit yang telah dikaji menghidapi hidrosefalus yang memerlukan *shunt* (n=41). Skor CHESS menunjukkan OR dari 2.184 dengan *p* value <0.001 memberikan nilai ramalan yang baik dan 2 faktor risiko lain didapati berkait rapat dengan terjadinya hidrosefalus bergantung shunt iaitu infark otak awal CT (OR 0.182; *p* value 0.004) dan

gred Fisher>3 (OR 1.986; *p* value 0.047). Taburan populasi skor CHESS bagaimanapun tidak mengikut data asal yang diterbitkan.

Kesimpulan

Di Malaysia, skor CHESS merupakan kaedah yang boleh digunakan dalam ramalan awal hidrosefalus yang memerlukan shunt selepas pendarahan subaraknoid.

ABSTRACT

Background and Objective

Chronic hydrocephalus caused by subarachnoid hemorrhage is a reversible and treatable condition. To date, existing clinical scores for predicting the development of post-hemorrhagic hydrocephalus are few and difficult to apply in the clinical settings. Chronic Hydrocephalus Ensuing Subarachnoid Hemorrhage Score (CHESS) was first published in 2015. Although it showed promising results, no external validation has been done outside Europe. We designed this study to validate the accuracy and reliability of CHESS score and to also look for other factors that may cause post-hemorrhagic shunt dependent hydrocephalus.

Methods

A total of 130 patients with acute subarachnoid haemorrhage from 2 tertiary neurosurgery centres in Malaysia were analysed using the parameters in CHESS score. The CHESS score was applied retrospectively and the results were compared with the patients' clinical data of development of shunt-dependent hydrocephalus. Results were analysed using binary logistic regression analysis and Goodness-of-Fit test to determine the predictive value and its distribution with the original data.

Results

Thirty one percent of the studied population developed shunt-dependent hydrocephalus (n=41). CHESS score showed a OR of 2.184 with *p* value of 0.000 and 2 other risk factors were found to be strongly related to development of shunt-dependent hydrocephalus i.e. early infarct in CT brain (OR 0.182 ; *p* value 0.004) and Fisher grade >3 (OR 1.986; *p* value of 0.047). However, the population distribution of CHESS score is not consistent with the data of the original author.

Conclusion

CHESS score is a reliable tool in early prediction of shunt-dependent hydrocephalus post subarachnoid haemorrhage in Malaysia.

1. INTRODUCTION & LITERATURE REVIEW

Post-haemorrhagic hydrocephalus (PHH) is a very common complication of aneurysmal subarachnoid haemorrhage (SAH). PHH develops following accumulation of blood in the subarachnoid space disrupting CSF hydrodynamics that may persist up to 50 days after the bleeding event(1) and contribute to prolonged morbidity in patients. Temporary diversion of CSF is a commonplace in such patients with a frequency of 15-87%(1,2), and about 31% patients will eventually require a permanent shunt(1).

Two studies(3,4) found different predictors for shunt dependency in cases of PHH and proposed a risk score system to estimate the need for shunt dependency. The Chan score(3) and the Dorai score(4) which were created did not gain much popularity due to the difficulty in completing the parameters within the scoring system or diagnostic inaccuracy(1). With a new scoring system called Chronic Hydrocephalus Ensuing Subarachnoid Score (CHESS)(1), the prediction of shunt dependency after SAH can be done within the first 72 hours. This can potentially be a useful tool in the management of PHH and subsequent decision-making on the need for permanent diversion of CSF in PHH.

Several studies(2–5) have attempted to look at the risk factors and ranked them accordingly into a usable scoring system to predict shunt dependency post SAH. However, none of the scoring systems succeeded in creating one good clinical usable scoring system until CHESS score was created by Jabbarli et al(1). The CHESS score was created based on 20 factors which influence shunt dependency PHH, of which only 5 factors were found to be significant and consistent with shunt dependency in patients. The positive and negative predictive value for this scoring system was shown to be more accurate than the Dorai score, Fisher score and Hunt and Hess grading in predicting shunt-dependent hydrocephalus(1). To date, no neurosurgical institution in Malaysia has used CHESS score for prediction of shunt dependency in PHH patients.

2. STUDY PROTOCOL

This is a cross sectional, retrospective study where patients who were admitted to between January 2014 to December 2016 for SAH in Department of Neurosurgery of Hospital Kuala Lumpur and Hospital Queen Elizabeth. These are tertiary training neurosurgery centers with neuroimaging modalities comprising of CT, MRI, angiogram and management modalities for neurosurgery with dedicated NeuroICU (Neuro-Intensive Care Unit). Patients who fulfilled the inclusion criteria stated below were enrolled.

Clinical data for the application of CHESS score will be collected: i.e. Hunt & Hess grade, location of ruptured aneurysm, acute PHH with CSF diversion, intraventricular hemorrhage, and early CT cerebral infarction on CT scan. CHESS score will be applied to the selected group of patients. Other parameters to be collected are gender, age, World Federation Neurosurgery Score (WFNS score), Fisher score, intracranial hematoma and treatment modalities. The analysed parameters are shown in Table 1.

The inclusion criteria were:

- Patients of all ages who were admitted for the first presentation of spontaneous non-traumatic SAH.
- Admission and treatment of the ruptured aneurysm of patients after the bleeding event.
- Survival up to the 60 days (median period for shunt) of patients from initial presentation.

The exclusion criteria were:

- Demise of patients during admission and treatment of the ruptured aneurysm.

- Patients who were admitted for traumatic SAH.
- Patients who were admitted for recurrent SAH.
- Demise of patients before the median period for shunt (< 60 days)

Sample Size

The sample size for this study was calculated based on the sample size calculator of sensitivity(6) and with the expected sensitivity of 0.9% from the CHESS score(1). Prevalence was set at 30%. Estimated sample size required was at 116**.**

Withdrawal criterias from this study were not applicable as only records of patients were analysed. No patient visits were required as this was a retrospective study.

This study was conducted over a period of 12 months from 1st January2017 to 31st December 2017. Data of patients was collected from January 2014 to December 2016 was collected. The timeline of study is shown in Figure 1.

Data analysis was performed with the use of SPSS statistical software. The Goodness-of-fit test was used to determine if the CHESS score for prediction of shunt dependency is distributed consistently with the original expected distribution(1). This will be significant if the p value >0.05 is found. Subsequently all the parameters were analysed using the binary logistic regression to look for parameters that has significant relationship in predicting shunt-dependent post-haemorrhagic hydrocephalus.

Declaration of Interest Conflict

There are no side effects on the participants as standard management for aneurysmal bleed will be applied and only the CHESS score will be counted. The outcome obtained will be used to compare the accuracy of the CHESS score. This study does not present any direct benefit to the participants. However, the study does provide a validation of the accuracy of the scoring system in relation to the outcome which may be used in the future.

This study was conducted in compliance with ethical principles outlined in the Declaration of Helsinki (2013) and the Malaysian Good Clinical Practice Guideline (2016). Approval was obtained prior to the initiation of this study. This is a retrospective study and therefore no patient consent is required.

Names of subjects will be kept on a password-protected database and will be linked only with a study identification number during this research. The patient identification number instead of patient identifiers will be used on data sheets. All data will be entered into a computer that is password protected. Names of patients will not be disclosed, and all will be changed into identification number instead. On the completion of study, data in the computer will be copied to a USB drive and other softcopies will be erased while the hardcopy data will be kept and locked in the office cabinet located in the Department of Neurosurgery, Hospital Kuala Lumpur for 2 years, after which, the data will be removed permanently.

TITLE PAGE

Review of CHESS score in SAH patients in local Malaysian Population

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3.2 Abstract

Background and Objective

Chronic hydrocephalus caused by subarachnoid haemorrhage is a reversible and treatable condition. To date, clinical scores available for predicting the development of post-haemorrhagic hydrocephalus are few and difficult to apply in the clinical settings. Chronic Hydrocephalus Ensuing Subarachnoid Haemorrhage Score (CHESS) was first published in 2016(1). Although it showed promising results but no external validation was done outside of Europe. We designed this study to validate the accuracy and reliability of CHESS score and to also look for other factors that may cause post-haemorrhagic shunt dependent hydrocephalus.

Methods

A total of 131 patients with acute subarachnoid haemorrhage from 2 centres in Malaysia were analysed using the parameters in CHESS score. The CHESS score was applied retrospectively, and the results were compared with the development of shunt-dependent hydrocephalus of patients. Results were calculated using binary logistic regression analysis and Goodness-of-Fit test to determine the predictive value and its distribution with the original data. Sensitivity and specificity for CHESS score were calculated too.

Results

Thirty one percent of the studied population developed shunt-dependent hydrocephalus (n=41). CHESS score showed a OR of 2.184 with p value <0.001 and 2 other risk factors were found to be strongly related to development of shunt-dependent hydrocephalus i.e. early infarct in CT brain (OR 0.182 ; p value 0.004) and Fisher grade >3 (OR 1.986; p value 0.047). However, the population distribution of CHESS score was not consistent with the data of the original author. The sensitivity and specificity for CHESS score in this cohort population showed a sensitivity of 73.2% and specificity of 93.3%. The area under the curve for CHESS score in our cohort is 0.922.

Conclusion

CHESS score is a reliable tool in early prediction of shunt-dependent hydrocephalus post subarachnoid haemorrhage.

Keywords

Shunt-dependent hydrocephalus; post haemorrhagic hydrocephalus; CHESS; risk factors; aneurysmal subarachnoid haemorrhage

3.3 Introduction

Subarachnoid haemorrhage is defined as blood within the subarachnoid space(7). This condition occurs due to the rupture of vessels which are located in the subarachnoid space and are commonly seen in aneurysmal rupture or post traumatic event. The former cause is usually more devastating and require further investigations if it is encountered. Because of this condition, the scores such as Fisher grade(8), Hunt and Hess grade(9) and World Federation of Neurological Surgeons score(10) were created to predict the different outcome of patients with SAH. The incidence of SAH is reported as 2-23 per 100 000 depending on the geographic location(11–13). SAH happens between the ages of 40-60 and the mean age is 55 years old(14). Females have a higher predilection(15).

Aneurysmal subarachnoid haemorrhage (SAH) remains a devastating condition with high morbidity and mortality rate. SAH is often associated with many complications such as hydrocephalus, rebleeding, cerebral ischemia and infarct(16–18), vasospasm, cognition impairment(19,20) and other non-neurological complications such as neurogenic pulmonary oedema, endocrinological disorders(21). Hydrocephalus in SAH often result in acute neurological decline in patients where patients require surgical intervention either with a temporary or permanent cerebrospinal fluid (CSF) diversion. Thus it is important to identify and treat the hydrocephalus early as it can cause a poor outcome if left untreated. The CHESS score allows the prediction of shunt dependency post PHH(1).

PHH is one of the complications of SAH and it requires temporary CSF diversion of up to 15%–87%(1,2). However, the CSF hydrodynamics disturbances within the central nervous system may persist for up to 50 days after the bleeding event, making permanent CSF diversion a requirement in 31% of SAH patients(1,2). There are several research(1,3,4,22)which have attempted to propose shunt predictors. and to create a unique risk score(3,4)for the calculation of the probability of shunt dependency, one of them being CHESS score(1). However, due to the use of clinically less applicable variables or diagnostic inaccuracy, these risk scores(3,4) were not accepted worldwide. On the other hand the CHESS score published recently has shown a good positive predictive value(1) in predicting shunt dependency post SAH but it has yet to be validated externally. Therefore if the CHESS score can be validated with good results as shown in the original paper, it will be a useful tool in guiding neurosurgeons in the management of patients with shunt dependent PHH.

CHESS score is a risk score which was created for early prediction of shunt dependency in post SAH patients by Jabbarli(1) as currently there are no system to predict shunt dependency in this group of patients. It was developed after analysing 23 early factors which were correlated with shunt-dependent hydrocephalus development of which only 5 parameters were found to be strongly related to development of shunt-dependent hydrocephalus in post SAH patients. These five parameters are poor Hunt and Hess grade, intraventricular haemorrhage, acute PHH requiring CSF diversion, posterior circulation aneurysm and early cerebral infarction on CT scan. This score was created based on retrospective data collected over a 5 years period in the Department of Neurosurgery, University Hospital Essen, Germany where two hundred and forty-two SAH patients were being treated. CHESS score has total 8 points: Hunt and Hess grade ≥IV (1 point), location of ruptured aneurysm in the posterior circulation (1 point), acute hydrocephalus requiring CSF diversion (4 points), intraventricular haemorrhage (1 point) and early cerebral infraction on CT scan (up to 24 hours post aneurysm treatment) (1 point). This result was then validated using an internal SAH cohort of 30 patients by the original author. The CHESS score demonstrated to have significant correlation with shunt-dependent hydrocephalus (*p* value =0.0007) and CHESS score of ≥6 showed significant higher risk in developing shunt-dependent hydrocephalus (*p* value <0.001)(1). CHESS score has yet to gain clinical acceptance worldwide because it still lacked of an external validation despite its proven accuracy statistically.

3.4 Methodology

3.4.1 Research design

This is a retrospective study. Approval was obtained from the Medical Research & Ethics Committee of the Ministry of Health Malaysia and registered in the national register for clinical trials registration ID: NMRR-16-2752-32572.The study aims to determine whether the CHESS score is a reliable tool to predict shunt-dependent PHH and also to look for any other parameters that have shown strong value in predicting shunt-dependent PHH.

3.4.2 Research location and duration

Data from patients who fulfilled the inclusion criteria from the 2 institutions i.e. Hospital Kuala Lumpur (HKL) and Hospital Queen Elizabeth (HQE), and treated for aneurysmal subarachnoid haemorrhage during the period of January 2014 to December 2016, were obtained and analysed. Department of Neurosurgery of HKL is Malaysia's largest neurosurgery centre where it consists of 3 operative theatres, 11-bed NeuroICU and 4 neurosurgery wards with 150 beds(23) whereas HQE is the second largest Neurosurgical institution in Malaysia housing 12-bed NeuroICU unit and 6 neurosurgery wards with 126 beds. Both centres are the regional neurosurgery referral centre with an average of 1000 neurosurgery cases being treated annually. These two centres were chosen for this study because both are tertiary centres where neurosurgical services are led by consultant neurosurgeons with facilities to perform exo- and endovascular treatment.

3.4.3 Study population

All patients who developed SAH who were admitted to HKL and HQE who fulfilled the inclusion and exclusion criteria were included in the study. The inclusion criteria for patients in this study were patients who were admitted and treated for the first presentation of aneurysmal bleed and patients who survived for up to 60 days from the initial ictus event. Patients who died during admission and treatment of ruptured aneurysm within the 60 days median period, SAH secondary to trauma and recurrent non-traumatic SAH were excluded from the study. Following the data from the original study, the median shunt rate for PHH is at 54 days(1), therefore the 60-day period of follow-up was used in this study.

3.4.4 Method of research

After the selection of patients, CHESS score was applied accordingly. The parts of CHESS score include Hunt and Hess score of more or equal to 4: Location of ruptured aneurysm (posterior circulation), acute PHH requiring CSF diversion, Intraventricular haemorrhage, early cerebral infarction on CT scan(1). The Hunt and Hess grading was collected by reviewing patients' clinical data on the admission clerking; location of the aneurysm was confirmed by the cerebral angiogram; acute PHH requiring CSF diversion was determined based on the CT brain; and external ventricular drain was inserted for the patient. Intraventricular haemorrhage and early cerebral infarction (within 24 hours post aneurysm treatment) were determined on the CT scans. The CT brain parameters from both centres were reviewed and reported by the oncall radiologists of the day and subsequently re-reviewed and reported by clinical radiologists with 3 years experience who were blinded to the initial report respectively. The interrater reliability for the radiologists in HKL and HQE were found to be reliable with the Kappa of 0.850 (p value <0.001) and 0.867 (p value<0.001) respectively. The CHESS for each patient was recorded solely by principal investigator**.** As the principal investigator is based in HKL, CHESS score data from HQE recording were done on a monthly basis by the principal investigator.

3.4.5 Statistical analysis

The recorded data were analysed using the SPSS (version 22, SPSS Inc., IBM, Chicago, IL, USA) statistical software. The Goodness-of-fit test was used to determine if the CHESS score for prediction of shunt dependency was distributed consistently with the distribution found in the original article(1). Other parameters i.e. Age, gender, location of aneurysm, Hunt & Hess score, Fisher score, WFNS score, acute PHH requiring CSF diversion, Intracerebral haemorrhage and intraventricular haemorrhage were put into the binary logistic regression analysis to determine the relationship of the parameters with shunt dependency. This is a stepwise method to look for significant parameter within the original CHESS score followed by other parameters which were not originally included in the CHESS score as shown in Table 4. The specificity and sensitivity of CHESS score in our cohort were calculated. Multilogic regression analysis was ran to determine the chances of shunting with CHESS score.

3.5 Results

During the period of study, a total of 131 patients were treated for post aneurysmal subarachnoid haemorrhage in the two aforementioned institutions. Of this group of patients, there were 41 patients (31.3%) who developed chronic post haemorrhagic hydrocephalus and required permanent CSF diversion. We observed 84 patients with a CHESS score of ≤6 who were not shunted where 7 patients with CHESS score of ≥6 were not shunted. In the group of patients with CHESS score ≥6, 30 patients underwent shunting while 11 patients with CHESS score of <6 were shunted. Table 2 shows the above stated findings and we concluded that 73.2% of patients with CHESS score of ≥6 were shunted while 93.3% of patients with CHESS score of <6 were not shunted (shown in Table 3).

Chi-square test and degree of freedom tests were done and the *p* value was calculated to be at 0.042. The *p* value of >0.05 indicates that the population distribution is distributed evenly with the original CHESS score population. Therefore it is concluded that the data of CHESS score for prediction of shunt dependency was not distributed evenly.

Binary logistic regression analysis studies the relationship between each of the variables with shunt dependency, variable which had the strongest relationship with shunt dependency was identified. CHESS score was found to have a *p* value of <0.001 and Odd's ratio of 2.184. It was also found that only 2 other variables had a statistically significant relationship with shunt dependency, namely early infarction on CT and Fisher score of >3 both with a *p* value of <0.05 and Odd's ratio of 0.182 and 1.986 respectively (shown in Table 4 and 5).

The sensitivity and specificity for CHESS score in this cohort population showed a sensitivity of 73.2% and specificity of 93.3%. The area under the curve for CHESS score in our cohort is 0.922 (Table 6) indicating a better diagnostic accuracy comparing to the area under the curve of 0.885 from the original CHESS score study(1).

The multilogic regression analysis for the CHESS score showed that an increment of a single point in CHESS score will lead to an increased chances of shunting by 2 times.

Moreover the likelihood of shunting is increased by 38 times in patients with CHESS score of more than 6 as shown in Table 7.

3.6 Discussion

Aneurysmal bleed and its complications have always been a challenge for neurosurgeons to manage and PHH is one of them. The difficulty faced by most neurosurgeons is in the decision-making process to identify the group of patients who will be shunt dependent. To date, no comprehensive and accurate diagnostic tool is available that is widely accepted in predicting the need for shunt in such patients. Many centres will typically manage these patients by gradually "challenging" the external ventricular drain (EVD) by increasing the height of the EVD to decide if the patients require shunt. Shunt placement in such patients can often be delayed due to multiple factors such as ventricle related factors i.e. ventriculitis, unfavourable CSF condition high protein count of >1.5 or heavily bloodstained CSF. Other systemic factors such as sepsis secondary hospital-acquired pneumonia, skin infections also come into play. All these factors will eventually lead to prolonged hospitalization(24,25) which is often due to repeated surgical interventions and complications associated with hydrocephalus and ventriculoperitoneal shunt(25). This also leads to the increase in medical treatment cost(26) which has an unfavourable financial implication for government-funded-tertiary centres i.e. healthcare providers in Malaysia and also patients' medical insurance. Failure to identify and treat the shunt dependent PHH patients promptly is associated with higher neurological morbidity(24,27). Therefore, there is a need for a tool to identify this group patients who are shunt dependent to reduce the morbidity caused by post haemorrhagic hydrocephalus. CHESS score was created as an adjunct for early diagnosis of shunt dependent hydrocephalus in post SAH patients. Earlier result published(1), it showed good predictive value based on the scores. In this study, the data collected from our patients was compared with the original data, and the comparison between the observed and expected number of patients was close but statistically it was considered otherwise(as shown in Figure 2).

As shown in the original article, CHESS score diagnostic accuracy was superior after it was compared with Dorai score, Hunt and Hess grade, Fisher grade and acute PHH as the single predictor of shunt dependency. CHESS score predictive value accuracy was further shown by another institution(28) whilst doing a study to create a new scoring system to predict shunt dependency PHH. Their results showed similar findings where it scored a p value of <0.001 with a OR of 1.533 giving it a good predictive value as stated in the original article. However, no comparison was made between CHESS score and Chan score.

Many authors(1,4,5,29–35) have documented different factors as related to shunt dependency post SAH and none obtained the same result in determining the factors related to development of shunt-dependent hydrocephalus. In our study, we noted that early cerebral infarction on CT and Fisher score has a strong relationship with development of shunt-dependent hydrocephalus post SAH. Early cerebral infarction on CT brain as a predicting factor was documented by Jabbarli and colleagues(1). Fisher score was not included in the CHESS score as it showed a non-statistical significance in predicting shunt dependency and was left out as a predicting score. However previous studies (17,36) has mentioned and reported that higher Fisher score is associated with higher shunt frequency which is consistent with what was found in our patients. Despite the differences of distribution found in our study population, the predictive value of CHESS score in shunt dependency post SAH is very good with a OR of 2.184 and p value of <0.001.

Analysis was done for each factor from the original score and it was found that other parameters from the original score had no statistical significant correlation with shunt dependency in PHH. Other factors such as age, gender, location of aneurysm(posterior), WFNS score, Hunt and Hess score, treatment modality(surgery), ICH, IVH, PHH did not show any statistical significant correlation with shunt dependency.

With the result from this study, we found that CHESS score predictive value is consistent with the published result(1). This is further confirmed and shown in the similar CHESS score population distribution of patients in this study and the published data(1). Our findings will help us in detecting shunt-dependent PHH early thus reducing the complications caused by hydrocephalus. Also because of the limited number of secondary and tertiary centres in Malaysia, application of CHESS score in our practice will reduce congestion in wards by expediting the decision making process for shunt dependency in post SAH patients. The CHESS score will also provide a clear and uniform management pathway for hydrocephalus in post SAH patients in centres in Malaysia owing to the easily replicable and reproducible scoring system regardless of the status of neurosurgery centre i.e. secondary or tertiary. Eventually this will alleviate the anxiety of family members and patients because of a clear and directed management pathway with reduction of time and financial burden.

As stated earlier, this study was conducted in a retrospective manner, a follow-up prospective study may be useful in further validating CHESS score accuracy and Fisher's score could also be incorporated in creating a new and better score to improve the reliability in prediction of shunt-dependent PHH.

3.7 Study Limitations

This is a retrospective study and data collected was validated retrospectively. Other contributory factors include the number of patients who were lost to follow up. In this study the median period of PHH development leading to shunt was set at 60 days in this study, based on the median period of 54 days from the original research(1). Thus, there is a possibility that chronic hydrocephalus may develop up to 1 year post SAH(26). Therefore in future a prospective cohort study with a longer period of data collection and observation of up to 1 year can be done in the future to further strengthen the accuracy of CHESS score.

3.8 Conclusion

The CHESS score is a reliable tool in predicting shunt dependency post SAH. It is simple and easy to apply and the result is available within 72 hours. Although this is a retrospective study, this score was applied and validated externally by our institution. The results are promising and a prospective study for application of CHESS score needs to be conducted to further evaluate its reliability.

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3.10 Tables

Table 1: Analysed Parameters

Age	• **>50 years old** • **<50 years old**
Gender	• **Male** • **Female**

Hunt and Hess score as seen on first CT scan done after aneurysm rupture	• **Good Grades:**
	  ○ **Grade 1:**
	    • Asymptomatic, Mild headache or nuchal rigidity
	  ○ **Grade 2:**
	    • Moderate to Severe Headache, no neurological deficit except for cranial nerves palsy
	  ○ **Grade 3:**
	    • Drowsiness, confusion or mild focal neurological deficit
	• **Poor Grades:**
	  ○ **Grade 4:**
	    • Stupor, moderate to severe hemiparesis, early decerebrate posture
	  ○ **Grade 5:**
	    • Comatose, decerebrate posture

Location of aneurysm rupture	• **Anterior circulation** • **Posterior circulation**
Acute Post-haemorrhagic-hydrocephalus requiring drainage	• **Yes** • **No**
Intraventricular haemorrhage as seen on the first CT scan done after aneurysm rupture	• **Yes** • **No**
Early Infarction on CT scan (up to 72 hours after the aneurysm rupture)	• **Yes** • **No**
World Federation of Neurosurgery Score (WFNS score) on admission	• **Good Grade:** o Grade 1: GCS score of 15 without focal deficit o Grade 2: GCS score of 13 or 14 without focal deficit o Grade 3: GCS score of 13 or 14 with focal deficit • **Poor Grade:** o Grade 4: GCS score of 7-12, any deficit o Grade 5: GCS score of 3-6, any deficit
Fisher score as seen on first CT scan done after aneurysm rupture	▪ **Good Grade:** o **Score 1:** ▪ No blood on CT scan

	◦ **Score 2:** ▪ Diffuse or thin layer of blood less than 1 mm thickness in the vertical plane (at interhemispheric, insular, or ambient cisterns) ▪ **Poor Grade:** ◦ **Score 3:** ▪ Localized clots and/or layers of blood greater than 1 mm thickness in the vertical plane (at interhemispheric, insular, or ambient cisterns) ◦ **Grade 4:** ▪ Intracerebral blood clot
Intracerebral haemorrhage as seen on the first CT scan done after aneurysm rupture	• **Yes** • **No**
Treatment modality	• **Surgical** • **Endovascular**

Table 2: Observed No. of Patients and its CHESS score

CHESS Score	Observed No of Patients
0-5 with Shunt	11
0-5 without Shunt	84
6-8 with Shunt	30
6-8 without Shunt	6
Total	131